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Late Cretaceous *Limea (Pseudolimea)* species of Europe

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Abstract

Four *Limea (Pseudolimea)* species [*L. (Ps.) composita, L. (Ps.) granulata, L. (Ps.) denticulata, L. (Ps.) geinitzi*] which occur frequently in Late Cretaceous strata of Europe, are redescribed. Attention is given to their origin, ecology and palaeobiogeographical distribution.
Key-words : Mollusca, Bivalvia, Limidae, Cretaceous, Taxonomy, Palaeobiogeography.

Résumé

Quatre espèces du groupe *Limea (Pseudolimea)* [*L. (Ps.) composita, L. (Ps.) granulata, L. (Ps.) denticulata, L. (Ps.) geinitzi*] se retrouvent fréquemment dans les dépôts du Crétacé Supérieur européen; elles sont redécrites, et une attention particulière est donnée à leur origine, écologie et distribution paléobiogéographique.
Mots-clefs : Mollusques, Bivalves, Limidés, Crétacé, Taxionomie, Paléobiogéographie.

Introduction

In the Cretaceous strata of Europe more northerly deposits often contain other faunal groups than those generally found in the Tethys. This is well documented for molluscan groups of traditional stratigraphic importance (Ammonites, Belemnites, Inoceramids). In the Lower Cretaceous two realms are generally recognised (CASEY & RAWSON, 1973). In the Upper Cretaceous most non-Tethyan deposits contain bivalve groups unknown in Tethyan deposits of the same age : these occurrences seem to be generally unrelated to the nature of the deposit (whether it concerns marls, sands, (white) chalks etc.).
Among the Pectinidae, Limidae and Ostreacea this faunal difference is particularly marked; several "smaller" genera (with species of relatively small average size) seem to thrive in "northern" (= Temperate) regions, but are virtually unknown in the Tethys. This applies f.i. to the pectinid genus *Microchlamys* SOBETSKI, 1977, (= *Lyropecten (Aequipecten) sensu* DHONDT, 1972 b), to the oyster *Agerostrea* VIALOV, 1936, to the limid subgenus *Limea (Pseudolimea)* ARKELL *in* DOUGLAS & ARKELL, 1932. Typical for this "northern" region (= Temperate region of KAUFFMAN *in* HALLAM, 1973) in Europe and western Asia are the white chalks of Coniacian-Maastrichtian (mainly Campanian-Maastrichtian) age, known as "Schreibkreide", "Skrivekridt" etc. The fauna found in this facies, probably because of the specific environment, contains "endemic" species (can be compared at least partially with "western European Endemic Center" of KAUFFMAN in HALLAM, 1973).
It is the purpose of the present paper to discuss the known Upper Cretaceous species of *Limea (Pseudolimea)* as an example of a group from the "northern European Province" (KAUFFMAN *in* HALLAM, 1973) and discuss the palaeobiogeography and evolution of this group within that province, and compare these with the occurrence outside the province.

Material and methods

The material used in this study comes mainly from museum collections (in appendix), but is sometimes complemented by recent field collections. The disadvantages of museum collections are well known : stratigraphic data are often incomplete, and random collections are virtually non-existent since the bias of collectors in the past was frequently towards "large" and/or "beautiful" specimens. However, in Europe the advantages of the same collections are that they often provide information on localities no longer accessible, and material which is the result of almost a century of collecting activities is bound to contain important information.
Many of the collections used for this study have been added to in recent years. They now include numerous specimens as a result of bulk collecting with precise stratigraphic data, as well as some historic specimens. This applies to the collections at Copenhagen, Greifswald, Hannover and Lwow, and to the Albert Kanaal collection from the Maastricht type-area, housed in the KBIN. The collections from the Pre-Caspian depression (Palaeontological Institute of the USSR Academy of Sciences, Moscow) and from Mangyschlack (Geological Faculty of Moscow State University) are new collections made in the same way. Species of *Limea* are small, and small species are rare in old collections, because they were often considered uninte-

resting by collectors in days gone by. However, the relative scarcity of small limid species in old collections cannot be ascribed only to their size. In modern bulk collections of very fossiliferous areas such as the Maastrichtian type-region, *Limea* specimens remain uncommon, but specimens of the equally small *Limatula* are more frequent. Yet, both genera are represented by a similar number of species. Therefore the explanation of the scarcity has to be found in the ecology of the *Limea* group.

Ecology of *Limea*

Limea in modern oceans is predominantly a deep-water genus. TEBBLE (1966, p. 69) noted that *Limea sarsi* LOVEN occurs "... in the North Sea and off the Shetlands in considerable depth", LAMY (1930) quoted data for several species, all pointing towards what he called ... "living in deep waters" ("eaux profondes"), NORDSIECK (1969, p. 56, 57) quoted precise data for *Notolimea crassa sarsi* (700-2664 m, Orkneys 270 m), for *Notolimea crassa laminifera* (810-1600 m).

In view of the depth at which recent *Limea* species are found, it seems safe to assume that the scarcity of *Limea (Pseudolimea)* specimens in Cretaceous strata could be due to the fact that they probably lived further offshore than most species found in greater numbers. This is at least partly proved by their occurrence : two species are mainly known from nearshore sediments *Limea (Pseudolimea) composita* from greensands and "tourtias" and *L. (Ps.) denticulata* from biocalcarenites. On the other hand two species from strata of latest Cretaceous age are almost typical "Schreibkreide" species : *L. (Ps.) granulata* and *L. (Ps.) geinitzi*. According to HÅKANSSON, BROMLEY & PERCH-NIELSEN (1974), the "Schreibkreide" could have been deposited as deep as 250 m.

Palaeobiogeography of Late Cretaceous *Limea*

The four *Limea (Pseudolimea)* species discussed in detail in the systematic part of this paper have been recorded from western Europe to west Kazakhstan (USSR, Central Asia). Tethyan occurrences seem exceptional : only *Limea (Pseudolimea) composita (*SOWERBY) is recorded from the Cenomanian of northern Spain; none of the Late Cretaceous species have been encountered from Tethys.

Limea (Pseudolimea) composita (SOWERBY), known from the Cenomanian, has a distribution which seems linked to deposits of the greensand type (KENNEDY *in* MCKERROW, 1978) (Text-Figure 1, p. 108).

Limea (Pseudolimea) granulata (NILSSON), has been recorded from the *Plenus* Zone (Late Cenomanian) to the latest Maastrichtian. It occurs in most lithologies (white chalks, marls and coarse-grained strata such as calcarenites), but from the Campanian onwards the species is more frequent in fine-grained facies. (Text-Figure 2, p. 111).

Limea (Pseudolimea) denticulata (NILSSON) has only been recorded from the Campanian to the latest Maastrichtian; it is as good as absent from the "Schreibkreide" facies, but occurs frequently in the coarse-grained deposits. In the biocalcarenites of the Maastrichtian type area it is the more common *Limea (Pseudolimea)* species (Text-Figure 5, p. 116).

Limea (Pseudolimea) geinitzi (von HAGENOW) has almost exclusively been recorded from the Maastrichtian. It is virtually restricted to the "Schreibkreide" facies, from northwestern Europe to Kazakhstan (Pre-Caspian depression, Aktiubinsk region). (Text-Figure 6, p. 118).

Evolutionary trends

In the Late Cretaceous of western Eurasia the oldest *Limea (Pseudolimea)* species is *Limea (Ps.) composita* (SOWERBY), from the Cenomanian, which is characterised by **trifid ribs**, and occurs relatively commonly in the "marginal non chalk-facies" (KENNEDY *in* MCKERROW, 1978) (sands, greensands, 'tourtias'). In the *Plenus* marls *Limea (Ps.) granulata* (NILSSON) appears. The replacement of species during the *Plenus* Zone (*Plenus* Zone 'event') is found in many Cretaceous pteriomorph bivalves (DHONDT, 1981) : at the end of the Cenomanian the Lower/Middle Cretaceous species of many lineages are replaced by Upper Cretaceous species. *Limea (Ps.) granulata* is in the same way as *L. (Ps.) composita* characterised by **trifid ribs**, but the ornamentation details on the ribs are different between the two species (Pl. 1, Figs. 4, 14). *Limea (Ps.) granulata* is a long-ranging species. Its last representatives are found in the latest Maastrichtian; it is known from calcarenites, marls and chalks.

In the Campanian of Scania (S. Sweden) *Limea (Ps.) denticulata* (NILSSON) is found. It has similarities with the previous two species, but is characterised by **undivided, sharply triangular ribs**, with granulations on the summits (Pl. 1, Fig. 12). From the Campanian to the latest Maastrichtian it has lived in environments which have fossilised as biocalcarenites and "greensands".

In the Maastrichtian "Schreibkreide" deposits of northern and eastern Europe and of west Eurasia *Limea (Ps.) geinitzi* (von HAGENOW) is found. It is slightly smaller than the previous species, and characterised by numerous, **undivided** and **rounded ribs.**

Systematic descriptions

Phylum **MOLLUSCA**
Classis **Bivalvia**
Subclassis **Pteriomorphia**
Ordo **Limoida**
Superfamilia **LIMACEA** RAFINESQUE, 1815
Familia **LIMIDAE** RAFINESQUE, 1815

Genus ***Limea*** BRONN, 1815.
Type species ***Ostrea strigilata*** BROCCHI, 1814 (M.).

Diagnosis of *Limea* (COX *in* MOORE, 1969, p. N389, fig. C106 : 7a, 7b) : "small, suborbicular or ovate, not gaping;

sculpture of radial ribs which crenate margin; cardinal area narrow; hinge with series of short denticles on each side; adductor impression subcentral. M. Trias. - Recent".

Genus ***Pseudolimea*** ARKELL *in* DOUGLAS & ARKELL, 1932.
Type species ***Plagiostoma duplicata*** SOWERBY, 1827.

Diagnosis of *Pseudolimea* (COX *in* MOORE, 1969, p. N391, fig. C107 : 3a, 3b) : "rather small, gibbose, obliquely ovate to orbicular; anterior umbonal ridge ill-defined; beaks near middle of moderately long cardinal area; ligament pit broad; hinge commonly with slightly oblique teeth occupying dorsal angles, but many specimens edentulous; ornament of angular ribs, commonly with thread in each interval. Trias. - Upper Cretaceous".

Discussion :
The difference between these two genera as defined by COX *in* MOORE, 1969 are slight, and are largely based on the shape of the ribs.
Among the many subgenera of *Limea* listed in the 'Treatise' none seems to have lived in the interval Middle Triassic to Upper Oligocene (*Limea* s.s. : Miocene to Recent, *L. (Eolimea)* : Middle Triassic, *L. (Escalima), L. (Gemellima), L. (Isolimea)* all three Recent, *L. (Notolimea)* : Upper Oligocene to Recent). *Pseudolimea* could be considered as the subgenus which fills this gap : its characteristics make this plausible and it makes phylogenetic sense, but it cannot be strictly demonstrated.
COX (1944) expressed the opinion that *Pseudolimea* and *Limea* are not directly related largely for reasons connected with the rib structure : "*Limea strigilata* is a small oblique trapezoidal shell ornamented with obscure radial threads with narrow interstices; it is quite unlike the strongly ribbed *Pseudolimea* in external characters" (COX, 1944, p. 76). Yet, in the 'Treatise', COX *in* MOORE (1969) has created in the genus *Limea* the subgenus *Eolimea* (from the Middle Triassic) which has strong ribs, and also the subgenera *Gemellima* and *Isolimea* (from Recent seas of Australia) can only be described as strong ribbed. Therefore I think that in view of COX's partially revised opinion, there is no reason to reject that *Limea* has as oldest subgenera *Eolimea* and *Pseudolimea*.

Limea (Pseudolimea) : **morphological characteristics of the species group and its variability :**

1. shell shape : rounded to obliquely ovate (opisthocline), depends partly on the age of the shell (or its size) : small individuals of any *Limea (Pseudolimea)* species are more orbicular than larger specimens, which show a tendency to obliquity : H (= UPD) grows faster than W; the convexity on the other hand seems to remain more or less constant.
2. hinge : the "denticles", left and right of the ligament pit, are nothing more than the crenulation marks of the auricular riblets on the inside of the auricular margins; the absence or presence of those crenulation-denticles depends on the preservation of the shell and on the number of auricular riblets : well preserved specimens of *Limea (Pseudolimea) reticulata* (FORBES, 1845) from the Ripley Fm. (Late Campanian of the Gulf Coastal Plains, USA) clearly show this.
3. ornamentation : consists of radial ribs which can be undivided or divided (normally trifid); some species have threadlike radial structures in the intercostal intervals; when the ribs are divided the trifid structure is most clearly visible on ribs situated in the median part of the shell; on the areas the ribs often remain undivided or even absent; the concentric striation crosses the ribs and the intercostal intervals : on the ribs the intersection points are marked as spines or granulations; the number of ribs varies slightly with the size of the shell within the same population : ribs are added on the areas (riblets become higher and broader and take the shape of a rib on the sides of larger specimens); also on larger, oblique specimens the ribs near the areas are narrower on the 'steep' area, but broader on the area which is sloping less abruptly (respectively, anterior and posterior areas, depending whether it concerns a right or a left valve); [see also COX (1944, p. 77) for discussion of the number of ribs].
4. difference between left and right valves : the shells are biconvex : the left and right valves fit into one another at the crenulations of the pallial margin; there seems to be virtually no difference between the two valves; however, anterior and posterior areas, especially in oblique specimens, vary in size.
5. auricles : small, equal to subequal, and generally covered with auricular riblets and concentric striation, but smooth on some species.
6. preservation : the Cretaceous taxa described in literature are often based on 'steinkern' material.

Differentiation of *Limea (Pseudolimea)*

Among the small limid genera found in Cretaceous and Eocene strata *Limea (Pseudolimea)* can be differentiated by :

- its obliquity and relative width from *Limatula* WOOD, 1835;
- its strongly developed ribs and suborbicular shape from *Limatulella* SACCO, 1898;
- its smallness and absence of gape from *Limaria* LINK, 1807.

Non-exhaustive list of Cretaceous *Limea (Pseudolimea)* species :

"Neocomian" species

1. *Limea (Pseudolimea) granulatissima* (WOLLEMANN, 1896) : figured in WOLLEMANN, 1900 (p. 37, pl. 2, figs. 4-5 and herein Pl. 1, Fig. 10) "Neocomian", Achim, near Braunschweig, Northern Germany.
2. *Limea (Pseudolimea) moreana* (d'ORBIGNY, 1847) (p. 438, pl. 416, figs. 6-10) : Upper "Neocomian", Saint-Dizier, Haute-Marne, France (in d'ORBIGNY's text also Aptian of Combles, Meuse, France).

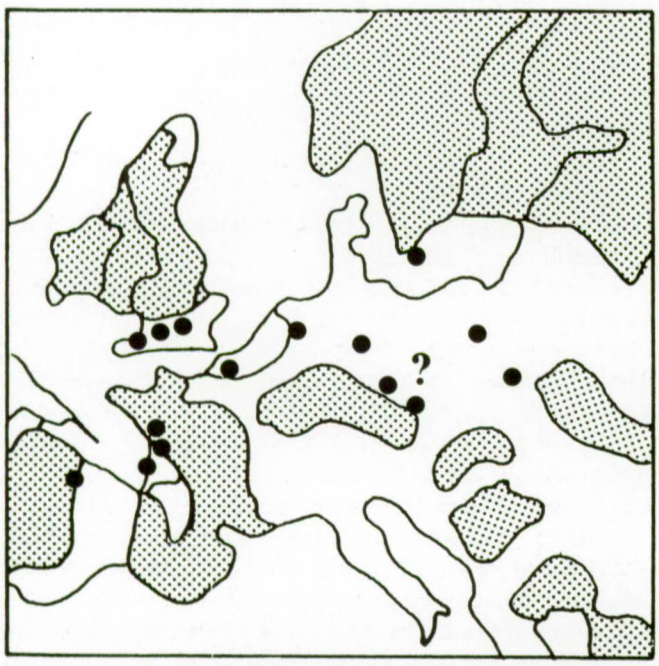
3. *Limea (Pseudolimea) exquisita* (de LORIOL, 1868) (p. 44, pl. 3, fig. 8) Valanginian, Arzier, Vaud, Switzerland.

Albian - Cenomanian (pars) species

4. *Limea (Pseudolimea) composita* (SOWERBY *in* FITTON, 1836) from the Cenomanian (discussed below).
5. *Limea (Pseudolimea) crenulicostata* (F. ROEMER, 1852) (p. 63, pl. 8, figs. 8a, b, c) Upper Albian, Neu Braunfels, Texas, USA.
6. *Limea (Pseudolimea) minuta* (GOLDFUSS, 1836) (p. 89, pl. 104, fig. 6) : the localities indicated by GOLDFUSS are "Rinkerode und Haldem, Untere Kreide"; these localities contain deposits which are generally classified as Upper Cretaceous; specimens which are identical with *L. (Ps.) minuta* as figured in GOLDFUSS, are known from Upper Cenomanian beds at Le Mans , Sarthe, France (GUÉRANGER coll.) and at Tournai, Hainaut, Belgium (IRScNB coll.). Until more and better material from this taxon is known a detailed discussion seems pointless.

Plenus Zone (latest) Cenomanian, Turonian, and younger species

7. *Limea (Pseudolimea) granulata* (NILSSON, 1827), from Plenus Zone to latest Maastrichtian (discussed below).
8. *Limea (Pseudolimea) circularis* HOLZAPFEL, 1889 (non *Lima circularis* EICHWALD, 1867) (p. 243, pl. 27, fig. 1) "Vaalser Grünsand", Campanian from near Aachen, GFR (could be closely related to *L. (Ps.) denticulata* (NILSSON, 1827).
9. *Limea (Pseudolimea) reticulata* (FORBES, 1845) (p. 62, text-figs.), original from the Campanian of New Jersey, USA; found in the Campanian-Maastrichtian of the Atlantic and Gulf Coastal Plains of the USA.
10. *Limea (Pseudolimea) denticulata* (NILSSON, 1827) Campanian and Maastrichtian (discussed below).
11. *Limea (Pseudolimea) aralensis* ARKHANGUELSKY, 1912 (p. 56, pl. 20, figs. 20, 26) Late Maastrichtian, Aral sea region, Kazakhstan, USSR (closely related to *L. (Ps.) denticulata).*
12. *Limea (Pseudolimea) geinitzi* (von HAGENOW, 1842) Maastrichtian, largely restricted to the 'Schreibkreide' (discussed below).
13. *Limea oldhamiana* STOLICZKA, 1871 (p. 423, pl. 30, figs. 6, 7, pl. 36, fig. 5), Ariyalur Group, Campanian-Maastrichtian of India.
14. *"Radula scrabicula"* STOLICZKA, 1871 (p. 419, pl. 30, fig. 8) Ariyalur Group, Campanian-Maastrichtian of India.
15. *Limea perlata* FRENEIX, 1980 (p. 29, pl. 3, fig. 8) "formation à charbons, sénonienne", Early Campanian of New Caledonia.



Text-Figure 1 : *Palaeogeographic distribution of* Limea (Pseudolimea) composita *(SOWERBY, 1836). Palaeogeographic reconstruction at 100 million years from* BARRON et al., *1981*

Limea (Pseudolimea) composita
(SOWERBY *in* FITTON, 1836)
(Pl. 1, Figs. 13, 14, 15, Text-Figure 1)

* 1836 *Pecten compositus* M. - SOWERBY *in* FITTON, p. 241, p. 342, pl. 17, fig. 20. (non 1836 *Pecten compositus* GOLDFUSS, p. 67).
v.1847 *Lima cenomanensis* d'Orbigny - d'ORBIGNY, p. 552, pl. 421, figs. 11-15.
(1850) *Lima cenomanensis* d'Orb.- d'ORBIGNY, p. 167, n° 437.
v.1870 *Lima cenomanensis* d'Orbigny - PICTET & CAMPICHE, p. 161, p. 168.
?(1871) *Limea Cenomanensis* Guéranger - STOLICZKA, p. 416.
.1882 *Limea cenomanensis* d'Orb.- WINDMOELLER, p. 24, p. 29.
v.1904 *Lima (Limea ?) composita* (Sowerby) - WOODS, p. 53, pl. 7, figs. 24a, b, 25a, b, 26.
.1911 *Lima pseudocardium* Reuss - FRIC, p. 41.
?1912-1913 *Lima pseudocardium* Reuss - SCUPIN, p. 235, pl. 12, fig. 16. (non 1845 *Lima pseudocardium* REUSS, p. 33, pl. 38, figs. 1-3, non 1850 *Lima pseudocardium* GEINITZ, pl. 21, figs. 11, 20 = *Limea granulata.*)
v.1925 *Lima (Limea) Yhri* n. sp. - RAVN, p. 28, pl. 1, fig. 3.
? pp.1937 *Lima (Mantellum) granulata* Nilsson - LEHNER, p. 178, pl. 22, fig. 20.
v pp.1939 *Lima (Limea) granulata* Nilss.- DACQUÉ, p. 37, pl. 1, figs. 7, 10, 11, non pl. 14, figs. 9, 10, nec pl. 16, fig. 30.
.1959 *Limea composita* (Sowerby) - FRENEIX, p. 227.
v.1987 *Pseudolimea composita* (J. de C. Sowerby) - CLEEVELY & MORRIS, p. 99, pl. 18, fig. 13.
non 1867 *Limea cenomanensis* GUÉRANGER, p. 19, pl. 24, fig. 9 = *Lima minuta* GOLDFUSS, 1836.

NOMENCLATIVE NOTE

The name given by J. de C. SOWERBY in 1836 was pre-employed. However, to stabilize nomenclature it seems at present preferable to continue the traditional usage, all the more so since SOWERBY's original assignment was in a wrong family.

TYPE MATERIAL

Lima composita : Bristol Museum (U.K.) (fide WOODS).
Lima cenomanensis : d'ORBIGNY Coll. 6421, Muséum national d'Histoire naturelle, Paris (France).
Lima yhri : Central Geologisk Institut, Copenhagen (Denmark).

LOCI TYPICI AND STRATA TYPICA

Lima composita : "probably Warminster" (Wiltshire, England) : *in* WOODS, 1904, p. 54. (If one accepts WOODS' interpretation of the type locality, the stratum typicum becomes Upper Greensand, Upper Albian - Lower Cenomanian).
Lima cenomanensis : Le Mans (Sarthe, France) : "couches inférieures de l'étage turonien du Mans" (Upper Cenomanian).
Lima yhri : Bornholm (Denmark) : "cenomane Basalkonglomerat" (probably Lower Cenomanian).

ORIGINAL DESCRIPTIONS

Pecten compositus : "Oblong; with about 20 smooth, sharp, radii and two rows of scales between each of them."

Lima cenomanensis : "*L. testâ ovatâ, transversâ, convexiusculâ, radiatim 40-costatâ; costis elevatis, angulatis, trifariàm granulatis; latere buccali convexo; auriculis subaequalibus.*
Dimensions. Largeur, 12 millim. - Par rapport à la largeur : longueur, 87/100; épaisseur, 61/100; longueur de la facette du ligament, 39/100. Ouverture de l'angle apicial, sans les oreillettes, 90°.
Coquille ovale, transverse, un peu renflée, ornée d'une quarantaine de côtes rayonnantes, anguleuses, pourvues, sur la partie médiane, d'une série de granulations; et d'une autre de chaque côté, près du sillon, qui est très-étroit. Région buccale non tronquée, saillante, sans excavations latérales; région anale un peu plus convexe que l'autre; région cardinale étroite, pourvue de deux oreillettes presque égales.
Rapports et différences. Cette espèce, par ses côtes pourvues de trois rangées de granulations, se rapproche beaucoup du *L. granulata*, mais elle s'en distingue par sa forme moins bombée, et par quarante côtes au lieu de vingt.
Localité. Je l'ai recueillie dans les couches inférieures de l'étage turonien des environs du Mans (Sarthe), où elle est assez commune."

ADDITIONAL DESCRIPTION

Numbers of specimens studied : 74, all of Cenomanian age. Belgium (3), Czechoslovakia (3), Denmark (2), England (26), France (30), Germany (4), Poland (2), Spain (2), USSR (2).

Measurements :
– Warminster, Upper Greensand, topotypes (BM).

UPD (mm)	W (mm)	AA	R (total)	R (large)
11.5	12.9	80°	31	21
13.4	13.0	91°	31	23
12.2	10.9	91°	32	17
15.3	14.2	94°	32	17
–	12.3	–	30	17

– Le Mans, Cenomanian, topotypes of *L. cenomanensis* (BM, Mans, Mus.Gen., Musé., NMW) :

UPD (mm)	10.4 to 25 (15.8)	average 14.1	(n=21)
W (mm)	9.6 to 13.7	" 11.65	(n=10)
HM (mm)	4.5 to 6.5	" 5.7	(n= 6)
AA	67° to 87°	" 77.4°	(n=11)
R	28 to 47	" 36	(n=19)

UPD/W varies from 1.0833 to 1.1533

Diagnosis :
Medium-sized *Limea (Pseudolimea)* species, suborbicular to subovate, globose, covered with around 30-45 ribs of which the central ones are trifid.

Ornamentation consists of 28 to 47 ribs, widely triangular to rounded in cross section, the central ones trifid, with on top, rows of relatively large scale-like spines, and, on each side of the rib, a row of small spines or granulations; those side rows lie at the base of the rib; when worn, the ribs are rounded and show no scales; the intercostal intervals are practically linear near the umbo, on specimens with many ribs, but near the pallial margin they are flat, smooth and narrower than the ribs; on specimens with relatively fewer ribs, the intervals are narrow but not virtually absent in the umbonal region; towards the sides of the disk (areas) the ribs fade and are replaced by one row of granulations or by an undivided rib; commarginal striae (growth lines) cover the shell but are only clearly visible on the areas and auricles.
Umbones, 65° to 95°, relatively pointed.
Auricles, subequal, normally incomplete.

DISCUSSION

Variability :
Shape : does not vary as much as in *Limea (Pseudolimea) denticulata* (see further); most specimens are subovate.
Ribs : – biological variation : the ribnumber varies strongly within this species, but it differs from locality to locality; not all the ribs reach the same development; those situated on the middle part of the shell are trifid, but the areal ribs are often undivided : this explains that SOWERBY indicated a ribnumber of 20 (only the trifid ribs were counted), whereas d'ORBIGNY indicated 40 (all the "ribs"); in the French specimens, however, the difference between centrally placed ribs and areal ribs is less well marked (could this more uniform rib structure be due to a somewhat finer-grained sediment ?).

– preservational variation : on 'steinkern' preservation the less developed areal riblets are often absent : thus the ribnumber seems smaller; the trifid rib arrangement, even with shell preservation, is sometimes difficult to see : on *badly* worn specimens the ribs look only rounded, on *slightly* worn specimens the ribs have often lost their row of spines on the top, while retaining the granulations on the sides of the ribs.
Umbones : variation seems unusually high, but this could be artificially induced by the difficulty of measuring them.

Synonymy :
Already WOODS, 1904 pointed out the identity of *Lima composita* (SOWERBY) and *L. cenomanensis* d'ORBIGNY. However, after examining the type material of *L. cenomanensis* GUÉRANGER (in Le Mans), I have to disagree with WOODS concerning that part of his synonymy : *L. cenomanensis* GUÉRANGER does not belong to the same species as *L. cenomanensis* d'ORBIGNY : the GUÉRANGER *Limea* species is very small, has about 12 undivided ribs and is probably closely related (or possibly synonymous) with *Lima minuta* GOLDFUSS from the Upper Cretaceous of Westphalia (see above).
Lima pseudocardium REUSS, is a taxon founded on 'steinkern' material which belongs in the *Limea composita-granulata* lineage. A few specimens with shell material preserved have allowed the distinction of the Lower and Middle Cenomanian specimens from those of the *Plenus* zone and younger strata : the former belong to *L. composita,* the latter to *L. granulata* (see below). The identifications of LEHNER (1937) and DACQUÉ (1939) are the result of synonymizing all specimens of *L. pseudocardium* with *L. granulata.* Their Cenomanian specimens are very poorly preserved, but as far as can be judged belong to *L. composita.*
Lima (Limea) Yhri RAVN is founded on a very small specimen; the preservation is not perfect but it shows sufficient characteristics to place it here.

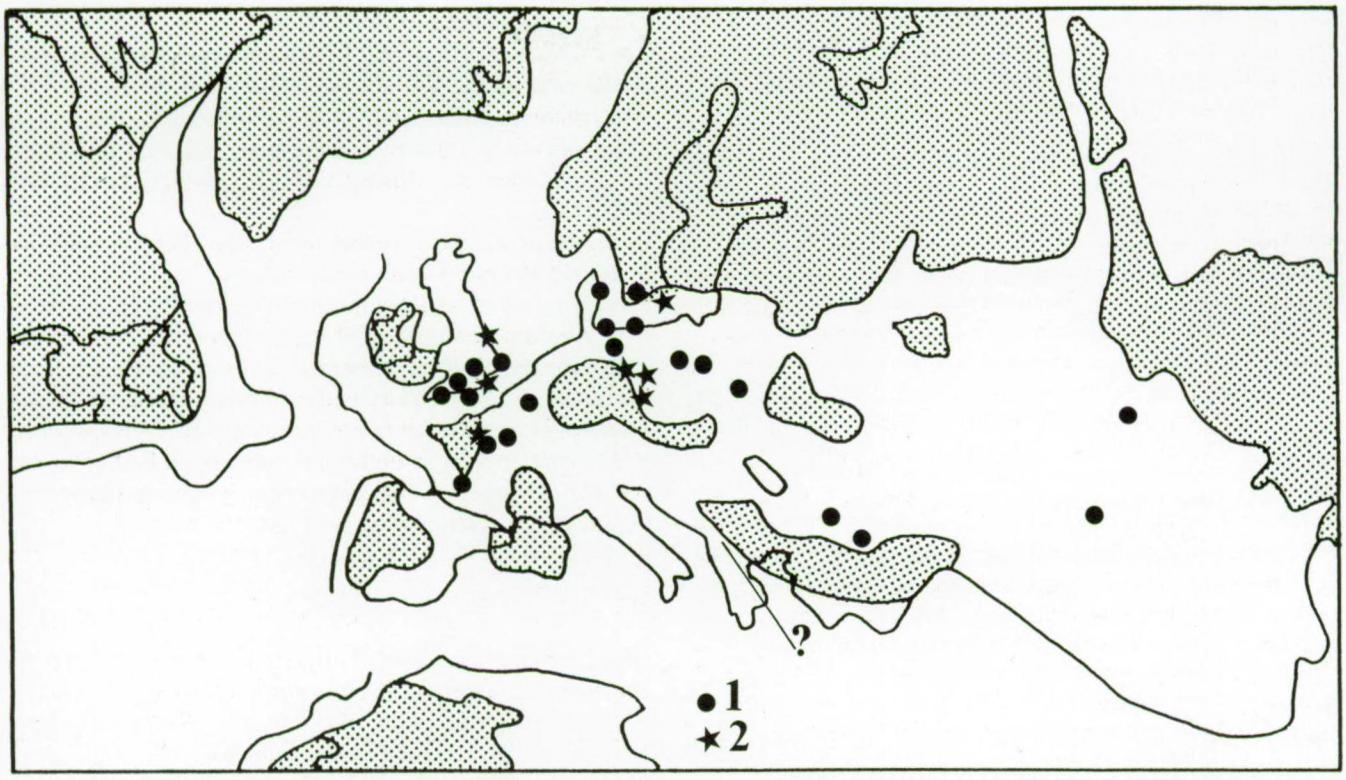
Comparison :
It is not easy to differentiate *Limea (Pseudolimea) composita* from *L. (Ps.) granulata* (NILSSON) : they have virtually the same number of tripartite/trifid ribs and the existing differences of rib structure can only be seen on specimens of good preservation. The best differentiating characteristic is in the intercostal intervals : virtually smooth in *L. (Ps.) composita,* but covered with scale-like granulations in *L. (Ps.) granulata.*
The species of the *L. cenomanensis* GUÉRANGER non d'ORBIGNY - *Lima minuta* GOLDFUSS lineage have noticeably fewer ribs.
L. (Ps.) crenulicostata (ROEMER) from the Albian-Cenomanian of Texas has undivided ribs, and this also applies to *L. (Ps.) denticulata* (NILSSON) (see below).

Generic attribution :
I have not seen *Limea* 'denticles', on the hinges of any of the specimens of *L. (Ps.) composita* examined by me; this could very easily be a matter of preservation.

Geographic and stratigraphic distribution :
Limea (Pseudolimea) composita appears to be restricted to the Cenomanian.
– Belgium : "Tourtia de Tournai" : Tournai, Hainaut (B; KBIN).
– Czechoslovakia : "Korycaner Schichten" : Korycany (Halle).
– Denmark : "Basalkonglomerat" : Bornholm (KO, also type-material of *Lima yhri* RAVN).
– France : Challey, Montoire, Loir-et-Cher (MusGen); Coulaines, Sarthe (MusGen) ; Le Mans, Sarthe (BM, Musé : also type-material of *L. cenomanensis* in the d'ORBIGNY coll., MusGen : also coll. PICTET, MusLaus, NMW); around Le Mans : Coulaines, Jalais-la-Butte, Les Perrais, La Trugalle, Savigné-l' Evêque (Mans, mainly coll. GUÉRANGER); Port-des-Barques, Charente-Maritime (Musé : also coll. d'Orbigny); Vailly-sur-Sauldre, Cher (BM); Val-au-Clair, Fécamp, Seine-Maritime (MusGen).
– GFR : Essen-Heissen, Ruhr (RE); "Cenomankalkstein" Umgegend von Regensburg (Mü, orig. DACQUÉ, pl. 1, figs. 10, 11).
– GB : 2 mls. E of Seaton, Devon (BM); Devizes, Wiltshire (BM); Dunstable, Bedfordshire (BM); Haldon, Devon (BM); Warminster, Wiltshire (BM, GeolSci : including WOODS' originals 8783, 8784, SM).
– Poland : Sygatka, Koniecpol (Instgeol).
– Spain : Rello, near Soria (Tüb).
– USSR : near Lwow, Ukraine (MusLwow).

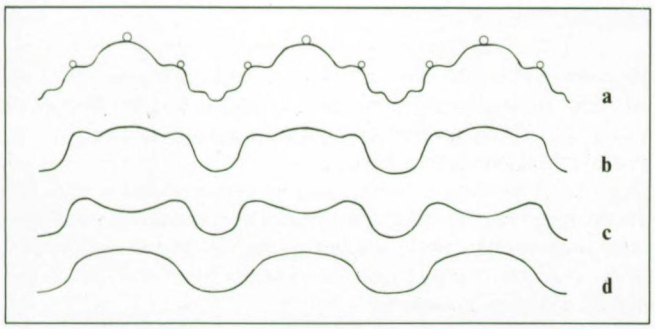
Limea (Pseudolimea) granulata (NILSSON, 1827)
(Pl. 1, Figs. 1, 2, 3, 4, 6, Text-Figures 2, 3, 4)

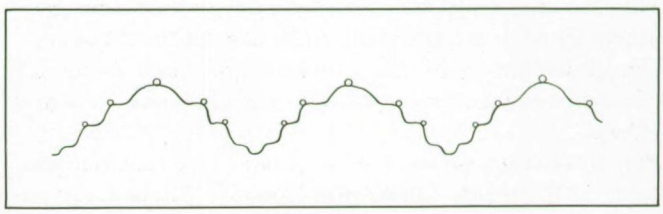
* 1827 *Plagiostoma granulatum* - NILSSON, p. 26, pl. 9, figs. 4a, b.
. 1833 *Plagiostoma granulosum* - WOODWARD, p. 48, pl. 5, pl. 26.
. 1836 *Lima granulata* Desh. - GOLDFUSS, p. 89, pl. 93, fig. 5.
. 1837 *Lima granulata* Duj. - DUJARDIN, p. 226, pl. 16, figs. 4a, b.
. 1837 *Lima ligeris* Duj. - DUJARDIN, p. 226, pl. 16, figs. 5a, b.
1839-1842 *Spondylus fimbriatus* - GEINITZ, p. 25 (non Spondylus fimbriatus GOLDFUSS).
? 1840 *Lima aequicostata* m.- GEINITZ, p. 82, pl. 20, figs. 40, 41.
1842 *Lima granulata* Desh. - von HAGENOW, p. 555.
p.p.? 1845 *Lima pseudocardium* Reuss - REUSS, p. 33, pl. 38, figs. 2, 3.
p.p.? 1845 *Lima aequicostata* Geinitz - REUSS, p. 33, pl. 38, fig. 1.
. 1846 *Lima granulata* Deshayes - REUSS, p. 32, pl. 38, fig. 21.
v. 1847 *Lima granulata* Deshayes - d'ORBIGNY, p. 570, pl. 427, figs. 5-9.
1849-1850 *Lima pseudocardium* Reuss - GEINITZ, p .190, n° 15.
1850 *Lima pseudocardium* Reuss - GEINITZ, pl. 21, figs. 11, 20.



Text-Figure 2 : *Palaeogeographic distribution of* Limea (Pseudolimea) granulata *(Nilsson, 1827) : 1 : Turonian - Santonian localities, 2 : Campanian - Maastrichtian localities. Palaeogeographic reconstruction at 80 million years from* Barron et al., *1981*

(1850) *Lima granulata* d'Orb.- d'Orbigny, p. 248, n° 768.
? 1851 *Lima pseudocardium* Reuss - J.Mueller, p. 67.
? 1851 *Lima inflata* Müller - J.Mueller, p. 68 (non *Lima inflata* Lamarck, 1807, nec *L. inflata* Petagna, 1819, nec *L. inflata* Fromherz, 1837 - fide Sherborn).
? 1851 *Lima dentata* Müller - J.Mueller, p. 68 (non *Lima dentata* G.B.Sowerby, 1843 - fide Sherborn).
(1855) *Lima granulata* d'Orb. - Cotteau, p. 102.
v. 1869 *Lima* spec. - Favre, p. 135.
. 1870 *Lima granulata* Nils. - Schlueter, p. 950.
(1871) *Lima granulata* Desh. - Pictet & Campiche, p. 170.
v. 1872 *Lima plauensis* Gein. - Geinitz, p. 204, pl. 43, figs. 5, 6.
v. 1872 *Lima pseudocardium* Reuss - Geinitz, p. 204, pl. 42, figs. 14, 15.
. 1876 *Lima granulata* (Nilsson) - Brauns, p. 386.
? 1876 *Lima pseudocardium* Reuss - Brauns, p. 386.
. 1883 *Lima iserica* Fr. n. sp. - Fric, p. 113, figs. 84 a, b.
. 1883 *Lima pseudocardium* Reuss - Fric, p. 113.
. 1888 *Lima granulata,* Deshayes - Péron, p. 147.
. 1888 *Lima Meslei,* Péron - Péron, p. 147, pl. 1, figs. 21-24.
1889 *Lima granulata* Nilsson sp. - Griepenkerl, p. 41.
. 1889 *Lima granulosa* Nilsson sp. - Holzapfel, p. 239, pl. 27, fig. 6.
1889 *Lima granulata* Desh. - Fric, p. 83, pl. 76.
1893 *Lima granulata* Deshayes - Fric, p. 100.
1894 *Lima granulata* Nilss. - Lundgren, p. 42.
. 1897 *Lima granulata,* Nilsson - Hennig, p. 26, pl. 2, figs. 6-8.





Text-Figure 3 : *Rib-section of* Limea (Pseudolimea) granulata *(Nilsson, 1827). a : well-preserved specimen, trifid ribstructure with globular structures on the summits of the ribs; b : shell is somewhat worn, rib summits almost worn off, intervals smooth; c : shell restricted to internal layer, ribsummit totally worn off, side - riblets partially remaining, general impression of double number of ribs, with alternating deep and shallow intervals; d : steinkern with undivided low ribs and shallow smooth intervals.*

Text-Figure 4 : *Rib-section of* Limea (Pseudolimea) granulata *(Nilsson, 1827) from Lower Maastrichtian strata in Trimingham, Norfolk, UK : ribs have double subdivisions resulting in 5 rows of globular structures, intervals very narrow.*

. 1898 *Lima granulata* Nilss. sp. - G.MUELLER, p. 29, pl. 4, fig. 6.
1901 *Lima granulata* Nilsson sp. - WOLLEMANN, p. 16.
1902 *Lima granulata* Nilsson sp. - WOLLEMANN, p. 57.
v. 1902 *Lima granulata* Nilsson sp. - RAVN, p. 101.
v. 1904 *Lima (Limea) granulata* (Nilsson) - WOODS, p. 54, pl. 7, figs. 27-29.
. 1909 *Lima (Limea) granulata* Nilsson - ROGALA, p. 693.
1921 *Lima (Limea) granulata* Nilss. sp. - RAVN, p. 20.
1923 *Lima granulata* Nilss. - JESSEN & ODUM, p. 34.
1930 *Lima (Limea) granulata* Nilsson - HÄGG, p. 35.
v. 1932 *Lima (Limea) granulata* Nilsson - WOLANSKY, p. 21.
. 1933 *Lima (Limea) granulata* (Nilss.) - HAENTZSCHEL, p. 123, pl. 4, figs. 9-11.
1934 *Lima granulata* Nilss. sp. - ANDERT, p. 149, pl. 8, figs. 8, 9.
1935 *Lima (Limea) granulata* Nilsson - HÄGG, p. 33.
p.p. 1937 *Lima (Mantellum) granulata* Nilsson - LEHNER, p. 178, pl. 22, fig. 20.
1938 *Lima granulata* Nilsson - CARLSSON, p. 7.
1939 *Lima (Limea) granulata* Nils. - DACQUÉ, p. 122, pl. 14, figs. 9, 10.
(1942) *Lima granulata* Nilss. - PUTZER, p. 371.
(1945) *Lima granulata* Nils. - JESSEN, p. 13.
1947 *Lima (Limea ?) granulata* Nilsson - HÄGG, p. 67.
. 1954 *Lima (Limea) granulata* (Nilsson) - HÄGG, p. 38, pl. 5, fig. 53.
1959 *Limea granulata* Nilsson - FRENEIX, p. 227.
1959 *Limea meslei* (Péron) - FRENEIX, p. 228.
1959 *Limea ligeris* (Dujardin) - FRENEIX, p. 228.
v. 1968 *Lima (Limea ?) granulata* (Nilsson) - PASTERNAK, p. 182, pl. 37, figs. 10-12.
. 1974 *Lima granulata* (Nilsson) - SAVCZINSKAJA, p. 96, pl. 28, figs. 12-14.
v? 1977 *Limea granulata* (Nilsson) - SOBETSKI, p. 109, pl. 7, fig. 7.
? 1981 *Limea granulata* (Nilsson) - TZANKOV *et al.*, p. 117, pl. 52, fig. 6.
v. 1982 *Pseudolimea granulata* (S. Nilsson) - DHONDT, p. 87, pl. 5, figs. 7, 8.
v. 1985 *Limea (Pseudolimea) granulata* (Nilsson) - DHONDT, p. 48.
. 1986 *Pseudolimea* (?) *granulata* (Nilsson) - ABDEL-GAWAD, p. 160, pl. 37, figs. 1-3.
v. 1987 *Pseudolimea granulata* (Nilsson) - CLEEVELY & MORRIS, p. 98, pl. 18, fig. 12.

TYPE MATERIAL

Plagiostoma granulatum : NILSSON's type specimens cannot be found at present in the collections of the Palaeontological Institution of the University of Lund (Sweden) (written communication of Dr. K. LINDHOLM, August 1981).
Plagiostoma granulosum WOODWARD : type material probably in the Castle Museum at Norwich, England.
Lima ligeris DUJARDIN : the whereabouts of the DUJARDIN coll. I have not been able to trace.
Lima aequicostata GEINITZ : GEINITZ's type-specimen could not be found in the collections of the Staatliches Museum für Mineralogie und Geologie in Dresden (GDR) which houses the GEINITZ coll. It remains possible that the figure was a reconstruction, made using several specimens.
Lima pseudocardium REUSS : lost.
Lima inflata MUELLER and L. dentata MUELLER : not found in the coll. of the Technische Universität, Aachen (GFR) which houses what is left of the Mueller coll.
Lima plauensis GEINITZ : in the type series of the Staatliches Museum für Mineralogie und Geologie in Dresden (GDR).
Lima iserica FRIC : probably in the Natural History Museum, Prague (Czechoslovakia).
Lima meslei PÉRON : the spécimen figured by PÉRON is in the Muséum national d'Histoire naturelle, Institut de Paléontologie in Paris (France). However, PÉRON created the name *L. meslei* explicitly for the specimen which DUJARDIN described as *Lima granulata*; the type specimen of *L. meslei* is thus by definition to be found in the DUJARDIN coll. However, if necessary the specimen figured by PÉRON can be chosen as a neotype.

LOCI TYPICI AND STRATA TYPICA

Plagiostoma granulatum : Kjugestrand (Sweden), "in petra conchacea et arenosa" (Campanian). (designated here).
Plagiostoma granulosum WOODWARD : Harford Bridges, Norfolk (England), (Upper Campanian).
Lima ligeris DUJARDIN : Touraine (France), "craie tufau" (Turonian-Santonian).
Lima aequicostata GEINITZ : Kutschlin, Czechoslovakia, "Hippuritenschichten" (Lower Turonian).
Lima pseudocardium REUSS : Kutschlin ?, Czechoslovakia, "Hippuritenschichten" (Lower Turonian).
Lima inflata MUELLER and *L. dentata* MUELLER : Vaals (Limburg, The Netherlands), "Mergel" (Lower Campanian).
Lima plauensis GEINITZ : Plauenschen Grund, Dresden (GDR), U. Quader-U. Pläner, Plenus-Zone (uppermost Cenomanian).
Lima iserica FRIC : Chorousek (Czechoslovakia), "Trigoniaschichten", Iserschichten (Jizera Formation, Turonian).
Lima meslei PÉRON : Saint-Paterne-Racan (Indre-et-Loire, France), "Craie de Villedieu" (Upper Turonian-Santonian).

ORIGINAL DESCRIPTIONS

Plagiostoma granulatum : "*P. testa obovato-rotunda, convexa, radiatim costata; costis trifariam granulatis.* Longit. 15. lat. 13 mm & ultra (Tab. nostra IX. fig. 4.A. magnitudine naturali. 4.B. frustulum magnitudine aucta).
Descript. Rotundata, convexa, radiatim costata, costis circiter 16-18, quarum singula ornatur tribus punctorum elevatorum seriebus, inter quas media ceteris aliquantum major. Margo undulatus , infra dentatus; rostrum basale acuminatum prominens. Auriculae parvae; lateribus granulatis.
Locus : In arena viridi ad Köpingemölla, haud raro; In petra conchacea & arenosa ad Kjugestrand passim."

Plagiostoma granulosum : WOODWARD gave no description.

Lima ligeris : "Testâ obovato-rotundatâ, convexâ, radiatim costatâ, lamellis transversis, trilobis, convertis in singulis costis.
Cette jolie espèce de lime se distingue par les petites lames

trilobées transversales implantées perpendiculairement sur les côtes; on ne peut donc la rapporter avec certitude au *Plagiostoma denticulatum* de Nilson, puisque dans sa description cet auteur dit seulement que les côtes sont dentées, et que la figure n'est pas assez précise pour qu'on puisse d'après cette figure comprendre autrement la structure de ses dents."

Lima pseudocardium : "Ist im Umriss der *L. (Plagiostoma) pectinoides* Sow. sehr ähnlich. 3 - 8' " hoch, breit eiförmig, etwas schief, hoch gewölbt, vorne steiler abfallend, sonst ohne deutlichen Hof, mit schlanken übergebogenen Wirbeln. Die selten sichtbaren Ohren klein, stumpfwinklig. Von Wirbel strahlen 40-50 gleiche, schmale, hohe, oben gerundete, senkrechte Rippen aus mit breiteren, am Grunde flachen Zwischenrinnen. Dichte, feine konzentrischen Linien laufen darüber. Auf der dünnen Schale bemerkt man auf der Höhe der Rippen auch sehr feine Längslinien.
Häufig im Hippuritenkalk von Kutschlin, im Plänersandstein von Hradek, Trziblitz, Tuchorzitz und Rannay, im Grünsandstein von Czencziz, Neuschloss, Semich, Malnitz und Laun, im grauen Kalkstein von Czencziz, im Exogyrensandstein von Malnitz, Drahomischel, Tuchorzitz und Koriczan, im untern Quader von Tyssa und Kreibitz; selten im untern Plänerkalk von Laun und in den Plänersandsteinbrocken aus dem Pyropenführenden Konglomerate von Meronitz."

Lima inflata J.MUELLER : "Die Gestalt dieser Species ist etwas schief-eirund, sie ist von den uns bekannten Arten die am meisten gewölbte. Die Buckel sind spitz. Die Oberfläche der Schalen sind mit 30-32 stark hervortretenden Rippen versehen, die von dem Buckel aus gleichmässig nach allen Seiten breiter werden und stark divergiren. Die breiten Furchen zwischen den Rippen erscheinen kahl, unter der Lupe laufen über das Ganze höchst feine concentrische Linien. Kommt vor im Mergel bei Vaels.".

Lima dentata J.MUELLER : "Die Form ist mehr gerundet als bei der vorstehenden Art. (i.e. *L. inflata*). Die Rippen, ungefähr gleich an Zahl, sind aber viel feiner, weniger stark hervortretend. Sie vereinigen sich ebenfalls in die Buckelspitze und divergiren nach den Rändern. Diese Rippen sind durch Anwachsstreifen durchkreuzt und bilden diese letztere in den sonst kahlen Zwischenfurchen einen dreieckigen Zahn. Die Ohren und die Spitze des Buckels waren abgebrochen. Vielleicht weiset sich das Petrefact in besser erhaltenen Exemplaren als ein *Cardium* aus. Im Mergel bei Vaels".

Lima iserica : "Diese neue Art, welche für die Trigoniaschichten sehr bezeichnend ist, ähnelt in Beziehung auf dem Steinkern sehr der *L. pseudocardium,* hat aber statt 40-50 bloss 20 Rippen, welche scharfkantig nicht abgerundet sind. Die Verzierung der Rippen besteht in drei Längsreihen von deutlichen Knoten, von denen die eine die Kante, die beiden anderen die Flanken einnehmen, während der Mitte des Zwischenraumes entlang auch eine solche Knotenreihe verläuft. Eben durch die letztere unterscheidet sich unsere Art von der *L. cenomanensis* d'Orb., welcher sie übrigens sehr nahe steht. Die französische Art ist viel ründlicher, breiter und besitzt an 40 Rippen."

ADDITIONAL DESCRIPTION

Numbers of specimens studied : 301.
Plenus Zone : GDR (89); Turonian : Czechoslovakia (13); Coniacian : England (1); Santonian : Denmark (5), England (15), France (12), GDR (17), GFR (2), Poland (1); Campanian : Belgium-The Netherlands (16), England (31), France (6), GFR (11), Poland (1), Sweden (12); Maastrichtian : Belgium-The Netherlands (12), Denmark (25), England (9), GDR (2), Poland (9), USSR (12).

Measurements :

– specimens from the Plenus Zone in Pennrich (GDR)

UPD (mm)	9.9 to 19.5,	average 14.6 mm	(N=16)
W (mm)	8.0 to 17.8,	average 13.0 mm	(N=16)
R	24 to 35 ,	average 28.7	(N=16)

– type series of *Lima plauensis* (DR) :
largest specimen : UPD (mm) 11

R	13 to 19,	average 15.5	(N=17)

– Turonian : CSSR (NMW) :

UPD (mm)	15.2
W (mm)	13.2
R	34

– Santonian : – Bornholm (KO) : W (mm) 7.8, R=19;
W (mm) 3.5, R=34.

– Saint-Paterne-Racan, Indre-et-Loire (Musé) :

UPD (mm) 9.8, W (mm) 8.7, R 29.

– Campanian : – Norwich, England (BM) :

UPD (mm)	8.4 to 20,	average 12.8	(N=8)
W (mm)	8.2 to 17.1,	average 12.07	(N=9)
AA	83° to 90°,	average 85.3°	(N=4)
R	19 to 33,	average 25	

– Barnakalla, Sweden (K0) :

UPD (mm)	13.8,	W (mm)	12.6,	AA 88°,	R	26
	14.2,		12.3,	—		24

– Obourg, Hainaut, Belgium (KBIN) :

W (mm)	6.8,	10.2,	12.
R	20	22	22.

– Maastrichtian : – "lunata - reef", Trimingham, Norfolk, England (SM)

UPD (mm) 21.4, W (mm) 19.9, AA 92°, R 26.

– Møen, Denmark (KO)

UPD (mm)	7.9 to 21.8,	average 14.6	(N=8)
W (mm)	6.6 to 20.5,	average 13.4	(N=8)
AA	73° to 88°,	average 85°	(N=7)
R	21 to 28,	average 22	(N=7)

– "Dania", Mariagerfjord, Denmark (K0) :

UPD (mm)	16.5,	W (mm)	14.8,	R 25
	21.7		19.5	25

– Lwow, Ukraine, USSR (MusLwow) :

UPD (mm)	21.4,	W (mm)	19.8,	R —
	24.3		20.7	24
	27.5		24.4	24

– Maastricht area, Belgium - The Netherlands (KBIN) :

W	(mm)	9.3,	9.9,	11.5,	12.8,	13.9,	15.1,	— ?
R		28,	27,	26,	24,	28,	33,	29.

Diagnosis : medium-sized *Pseudolimea* species, subovate to suborbicular, globose, covered with 20 to 40 trifid ribs, separated by intercostal intervals which are covered with scales.

Ornamentation : – strong trifid ribs with narrow intercostal intervals; each rib in the middle part of the shell bears three (sometimes five) rows of pointed scales : the largest scales are on the row at the summit of the rib; the rows on the sides of the ribs have somewhat smaller scales; if 5 rows are present the lowest rows bears the smallest scales; those scales lie on commarginal lines. On the lateral parts of the shells the ribs are often undivided; „hen one row of scales remains it is the summit row, but often this single row of scales are larger than the scales on those ribs which are trifid;
– many specimens because of the incomplete preservation give the impression of single ribs;
– when worn, ribs give the impression of being more numerous (Text-Figure 5).
Umbones : fairly wide;
Auricles : small and subequal, when visible.

Discussion :

Variability :
shape, is relatively rounded : *L. (Ps.) granulata* is suborbicular to subovate and it is the most globose of the Cretaceous *Pseudolimea* species;
umbones : the suborbicular shape results in a wider umbonal angle (70° to 100°);
rib number : varies widely when areal riblets are counted as ribs : the number of those riblets increases with the size of the specimen; hence, roughly, the larger the specimen, the higher the number of ribs (and the easier it is to count them accurately ! — human factor —);
preservation variation : – on steinkern preservation areal riblets are sometimes completely absent, but depending on the moment of fossilisation the main ribs seem to consist of two ribs rather than of one trifid rib (Text-Figure 3);
– on very worn specimens the ribs seem to be simple (as on *Limea (Pseudolimea) composita* (Pl. 1, Fig. 13, Text-Figure 3).
rib shape : slight differences between right and left valves; areal riblets are generally undivided; in certain deposits (Upper Campanian in Norwich f.i.), the central ribs of large specimens are not trifid, but partly divided in five unequal parts : two thin riblets are added at the base of the side of the rib (Text-Figure 5).

Synonymy and comparison :
compared with other *Limea (Pseudolimea)* species, *L. (Ps.) granulata* has a long stratigraphic range (*Plenus* Zone to latest Maastrichtian). The species has good differentiating characteristics, and therefore the long range is unusual and almost surprising. However, *L. (Ps.) granulata* was obviously able to live successfully in different environments now seen as marls, chalks, calcarenites and greensands. This might explain the long range. Woods (1904) pointed out the identity between Woodward's *Plagiostoma granulosum* and Nilsson's *Pl. granulatum*. The type of *Lima ligeris* Dujardin is lost : the description makes plausible that *Lima ligeris* is a younger synonym of *L. (Ps.) granulata; Lima granulata* Dujardin was renamed *Lima meslei* by Péron (1888) : the "differences" indicated by Péron to exist between the *L. granulata* Dujardin and *L. granulata* Nilsson are slight, and I consider that they fall within the normal specific variability.
Geinitz (1839-1842) described several taxa which Reuss (1845) already stated to be synonyms, and then gave one name to the species of Geinitz - "*Lima pseudocardium*" : an unfortunate taxon, because most of the material it originally included is of steinkern preservation, and hence does not allow the differentiation between *Limea (Ps.) composita* and *L. (Ps.) granulata*. Material of better preservation was found later, and it shows that *L. pseudocardium* specimens from the *Plenus* Zone undoubtedly belong to *L. (Ps.) granulata* (Pl. 1, Figs. 1, 2, 3). *Lima plauensis* Geinitz, 1872 is also synonymous with *L. (Ps.) granulata*, as can be seen when studying the type series from the *Plenus* Zone from Plauen, Dresden (GDR).
Holzapfel (1889) proved the identity of the taxa *Lima pseudocardium, L. inflata, L. dentata* used by J. Müller (1851) for specimens from the Campanian of Vaals with *L. (Ps.) granulata. Lima iserica* Fric, 1883 was erected for specimens of *L. pseudocardium* Reuss, but with shell preservation (Fric, 1883, p. 113); the seemingly different rib number is due to the variability (see above, under that heading). The name *Lima granulosa* in Holzapfel, 1889 is a *lapsus calami* for *L. granulata*.
The material studied by Sobetzki, 1977 is poorly preserved and makes definite specific identification impossible.
Stoliczka (1871) and Woods (1904) already stated that *Lima scrabicula* (Stoliczka) from the Ariyalur Group in India is very close to *L. (Ps.) granulata;* this probably also applies to *Limea oldhamiana* Stoliczka from the same Indian strata.
Though differentiation between *L. (Ps.) composita* and *L. (Ps.) granulata* is not always easy, the latter species is on average more globose and its ornamentation consists generally of scales rather than of small spines.

Generic attribution :
As for *Limea (Pseudolimea) composita.*
Geographic and stratigraphic distribution : Limea (Pseudolimea) granulata has been found in strata ranging from the *Plenus* Zone to the latest Maastrichtian
Plenus Zone :
– GDR : Bannewitz (orig. of Geinitz (1872, pl. 42, figs. 14, 15, sub *Lima pseudocardium,* DR), Koschütz (DR), Ockerwitz (DR), Pennrich (DR), Plauen (Dr, also type series of *Lima plauensis*), Rabenau-Forst (DR), Ratssteinbruch-Dresden (DR).

Turonian :
- Czechoslovakia : Kutschlin (B, NMW), Laun (= Louny) (NMW), Malnice (Halle), Trziblitz (NMW).
- GDR : Altfranken-Dresden (B), Cotta (DR), Elbstollen (B), Naundorf bei Pirna (NMW).

Coniacian :
- GB : Dover, Kent, *Cortestudinarium* Zone (BM).

Santonian :
- Denmark : Bornholm : Forchammer Odde (KO), Stampen (KO), Vest for Bavnodde (KO).
- France : Saint-Paterne-Racan, Indre-et-Loire (Mans, Musé, also orig. of PÉRON, 1887, pl. 1, figs. 21-24), Villedieu, Loir-et-Cher (MusGen).
- GB : *Coranguinum* Zone : Broadstairs, Kent (SM), Flamborough, Yorkshire (BM);
  Uintacrinus Band : Thanet Coast, Kent (BM);
  Marsupites Zone : Thanet Coast, Kent (BM).
- GDR : Salzberg, Quedlinburg (B, Halle).
- Poland : Neu-Warthau, Silesia (B).

"Senonian" :
- GFR : Haldem (SM, MÜNSTER Coll. sub *Lima elongata*), Rinkerode (SM, MÜNSTER Coll. sub *Lima minuta*).

Campanian :
- Belgium : Craie d'Obourg : Cuesmes, Hainaut (KBIN), Harmignies, Hainaut (KBIN).
- France : Chavot, Marne (Musé, d'ORBIGNY Coll. 7564), Meschers, Charente (MusLaus), nr. Saintes, A10 (KBIN).
- GB : *quadrata* Zone : Claydon, Ipswich, Suffolk (BM), East Harnham, Salisbury, Wiltshire (BM);
  mucronata Zone : Alderbury, Salisbury, Wiltshire (BM, also original WOODS, 1904, pl. 7, fig. 29), Alum Bay House, Isle of Wight (SM), Attoe's Pit, Norwich, Norfolk (BM), Ballard Head, Dorset Coast (BM), Catton, Norwich, Norfolk (BM), Clarendon, Salisbury, Wiltshire (BM), Cunnell's Pit, Newmarket Road, Norwich, Norfolk (BM), Dereham Road, Norwich, Norfolk (BM), Harford Bridges, Norwich, Norfolk (BM), Mousehold, Norwich, Norfolk (BM), Norwich, Norfolk (SM, also original WOODS, 1904, pl. 7, fig. 28), Scratchell's Bay, Isle of Wight (BM), Studland Bay, Dorset Coast (BM), Whitlingham, Norwich, Norfolk (BM).
- GFR : Ilsenburg (DR), Lüneburg (B, RM).
- Poland : Okale (InstGeol).
- Sweden : Barnakalla (BM), Hanaskog (KO), Ignaberga (KO), Kjuge (KO), Köpinge (B), Maltesholm (KO).

Maastrichtian :
- Belgium - The Netherlands : Eben-Emael, Limburg (KBIN), Maastricht (B), Pesaken (KBIN), Slenaken (KBIN), Sint Pietersvoeren, Limburg (KBIN).
- Denmark : Aalborg (KO), "Dania", Mariagerfjord (KO), Gudumsholm (KO), Moen (KO), Norre Uttrup (KO), "Glacial boulder", Fyen (KO), Skovbakken (KO), Stevns Klint (KO).
- GB - *lunata* Zone : between Trimingham and Mundesley, Norfolk (SM), Trimingham, Norfolk (BM, SM).
- GFR : Hemmoor (Hann).
- GDR : Rügen (B, HAGENOW Coll., DR).
- Poland : Okale (MuzWar), Piotrawin (MuzWar), Predmiescie Blisne (MuzWar), Solec (MuzWar), Sulejow (MuzWar).
- USSR : W. Ukraine : near Lwow : Gruboitschi, Matrochin, Mokrotin, Poletisch (all specimens in MusLwow), Nagorzany (MusLwow, NMW, orig. of FAVRE, 1869 sub Lima sp.); Aktiubinsk Obl., Precaspian Depression, West Kazakhstan : several specimens (PIN); Mangyschlack, West Kazakhstan : Supu kapi (PIN; MGU).

Limea (Pseudolimea) denticulata (NILSSON, 1827)
(Pl. 1, Figs. 7, 8, 9, 11, 12, Text-Figure 5)

* 1827 *Plagiostoma denticulatum* - NILSSON, p. 26, pl. 9, figs. 5a, b.
. 1827 *Plagiostoma pusillum* - NILSSON, p. 26, pl. 9, fig. 6.
. 1847 *Lima Dutempleana* d'Orbigny - d'ORBIGNY, p. 571, pl. 427, figs. 10-14.
? 1847 *Lima pectinata* d'Orbigny - d'ORBIGNY, p. 572, pl. 427, figs. 15-19.
(1850) *Lima Dutempleana* d'Orb. - d'ORBIGNY, p. 248, n° 769.
(1850) *Lima pectita* (sic) d'Orb. - d'ORBIGNY, p. 248, n° 770.
v. 1860 *Lima pseudocardium* - BOSQUET, n° 448. [non *L. pseudocardium* REUSS = *L. granulata* (NILSSON)].
1889 *Limea denticulata* Nilsson sp. - GRIEPENKERL, p. 41.
. 1895 *Lima (Limatula ?)* cf *denticulata* Nilss.- VOGEL, p. 19, pl. 1, fig. 13.
. 1897 *Lima denticulata* Nilss. em. Hennig - HENNIG, p. 32, pl. 2, figs. 19-23.
v. 1902 *Lima denticulata* Nilsson emend. Hennig - RAVN, p. 10.
? 1912 *Limea aralensis* sp. n. - ARKHANGELSKII, p. 56, pl. 20, figs. 20, 26.
v. 1932 *Lima (Limea) denticulata* Nilsson emend. Hennig - WOLANSKY, p. 21, pl. 3, figs. 6, 7.
1934 *Lima (Limatula) denticulata* (Nilsson) - HÄGG, p. 31.
1947 *Lima (Limatula) denticulata* (Nilsson) - HÄGG, p. 66.
1954 *Lima (Limatula) denticulata* (Nilsson) - HÄGG, p. 37.
1959 *Limatula pectinata* (d'Orbigny) - FRENEIX, p. 226.
1959 *Limatula dutempleana* (d'Orbigny) - FRENEIX, p. 226.
. 1981 *Limea denticulata* (Nilsson)- TZANKOV *et al.*, p. 117, pl. 52, figs. 7, 8.
. 1982 *Pseudolimea denticulata* (S. Nilsson) - DHONDT, p. 88, pl. 5, figs. 5, 6.

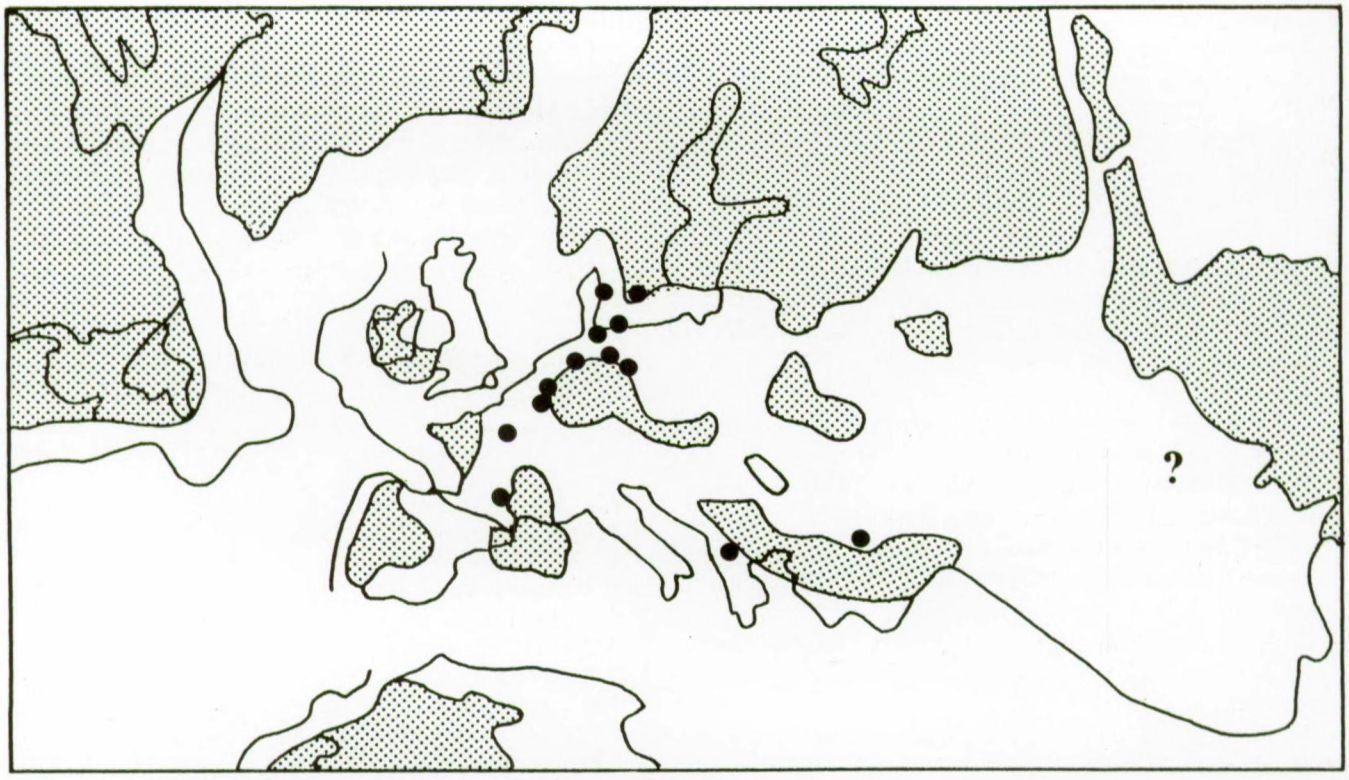
TYPE-MATERIAL

Plagiostoma denticulatum and *Pl. pusillum* : cannot be found in the Palaeontological Coll. of the University of Lund, Sweden at present (written communication of Dr. K. Lindholm, August 1981). A neotype should be selected preferably from Ignaberga, if the original cannot be recovered.

Lima dutempleana and *Lima pectinata* : according to d'ORBIGNY the original specimens were in the collection of M. Dutemple, the whereabouts of which I have not been able to find. The d'Orbigny coll. (Musé) contains no specimens of these taxa, so neotypes cannot be selected from it.

LOCI TYPICI AND STRATA TYPICA

Limea denticulata : Ignaberga (Sweden); stratum typicum :



Text-Figure 5 : *Palaeogeographic distribution of* Limea (Pseudolimea) denticulata *(Nilsson, 1827). Palaeogeographic reconstruction at 80 million years from* Barron et al., *1981*

not indicated in the original publication; according to Hägg (1954) : "Mammillatenkreide", according to Kegel Christensen (1975) : upper Lower Campanian.
Limea dutempleana and *L. pectinata* : Chavot (Marne, France), "couches supérieures de l'étage sénonien" : here : Upper Campanian.

ORIGINAL DESCRIPTION

Plagiostoma denticulatum : "*P. testa obovato-rotundata, radiatim costata; costis acutis, medio denticulatis.* Long. 11. lat. 10 mm (Tab. nostra IX, fig. 5A, B.)
Descript. Quoad ambitum & convexitatem antecedenti (1) similis; radiatim quoque costata est, sed costarum numerus major (circa 26-28); singula costa dorso angulato, & angulus dentium serie, ornatur. Latera antera auriculas rugoso-striata.
Locus : Ad Ignaberga & Kjugestrand rarius."

(1) *Limea granulata* (Nilsson)

Plagiostoma pusillum : "*P. testa obovato-rotundata, convexa, radiatim costata; costis tereti-convexis, & sulcis transversim tenuiter striatis.* Long. 9, lat. 8 mm (Tab. IX, fig. 6A, 6B).
Descript. Ad antecedentem (2) proxime accedit, cujus tamen varietas vix esse potest. Differt enim costis circiter 20, tereti-convexis, non angulatis, sed transversim tenuissime striatis, quae tamen in sulcis interjacentibus praecipue conspiciuntur.
Locus. Ad Ignaberga, Balsberg, Köpinge. Minus quam praecedens, species rare esse videtur.

(2) *Limea denticulata* (Nilsson)

Lima dutempleana : "*L. testâ ovato-rotundatâ, inflatâ, radiatim 21-costatâ; costis aequalibus, elevatis, carinatis, granosis; lateribus convexis.*
Dimensions : Largeur, 6 millim. - Ouverture de l'angle apicial, sans les oreillettes, 70°.
Coquille ovale, un peu trigone, transverse, très-convexe, ornée d'environ vingt côtes rayonnantes, égales, élevées, carénées, et pourvues sur leur convexité d'une rangée de petits tubercules granuleux. Sillons intermédiaires très-étroits. Les deux côtés sont peu différens.
Rapports et différences. Voisine, par sa forme et par son ensemble convexe, du *L. granulata,* cette espèce s'en distingue par ses côtes pourvues d'une seule rangée de tubercules au lieu de trois.
Localité. Elle paraît propre aux couches supérieures de l'étage sénonien, et a été découverte à Chavot (Marne), par M. Dutemple.
... de la collection de M. Dutemple".

Lima pectinata : "*L. testâ ovatâ, tranversâ, convexiusculâ, radiatim costatâ; costis numerosis, aequalibus, carinatis, tuberculatis; lateribus subaequalibus.*
Dimensions. Largeur, 11 millim. - Par rapport à la largeur : longueur, 72/100; épaisseur, 35/100.
Coquille ovale-oblongue, tranverse, régulière, assez convexe, ornée de côtes rayonnantes très-nombreuses, très-serrées, carénées en dessus et pourvues, à cette partie, d'une série de tubercules saillans, séparées par des sillons très-étroits. Les deux côtés ainsi que les oreillettes sont presque égaux de forme.
Rapports et différences. Cette espèce, par sa forme presque équilatérale, se rapproche du *L. semisulcata,* dont elle se distingue néanmoins par toute sa surface couverte de petites côtes granuleuses.
Localité. Propre aux couches supérieures de l'étage sénonien, elle a été recueillie à Chavot (Marne), par M. Dutemple; près de Sens (Yonne) par moi.
... de la collection de M. Dutemple."

ADDITIONAL DESCRIPTION

Number of specimens studied : 115.
Santonian, GDR (7); Campanian : France (3), GFR (14), Sweden (37); Maastrichtian : Belgium-The Netherlands (50), Denmark (4), GFR (fragments).

Measurements :
The difference between left and right valves is slight; hence, for the measuring, no distinction has been made :

– Kristianstad area, Scania, Sweden, mainly KO coll., Campanian :

UPD : min. 5.0 mm, max. 9.2 mm, av. 6.7 mm (N=17)
W : min. 4.4 mm, max. 8.2 mm, av. 5.7 mm (N=18)
HM : when UPD = 7.6 mm, HM = 3.6 mm
when UPD = 6.4 mm, HM = 3.3 mm
R : min. 22, max. 33, av. 26.2 (N=22)
AA : min. 67°, max. 90°, av. 77.6° (N=13)

– Maastricht - Sint Pietersberg - Albertkanaal, Belgium - The Netherlands, specimens from B and KBIN coll., Late Maastrichtian (Maastricht Fm.) :

UPD : min. 8.4 mm, max. 22.7 mm, av. 13.4 mm (N=16)
W : min. 3.8 (7.2) mm, max. 20.5 mm, av. 11.2 (N=21)
R : min. 20, max. 41, av. 28.5 (N=20)
AA : min. 56°, max. 89°, av. 74.7° (N=16)

Sample sizes are comparable, but the specimens from the Maastricht area reach significantly larger sizes than those from Scania; the other measured characteristics fall within normal variability.

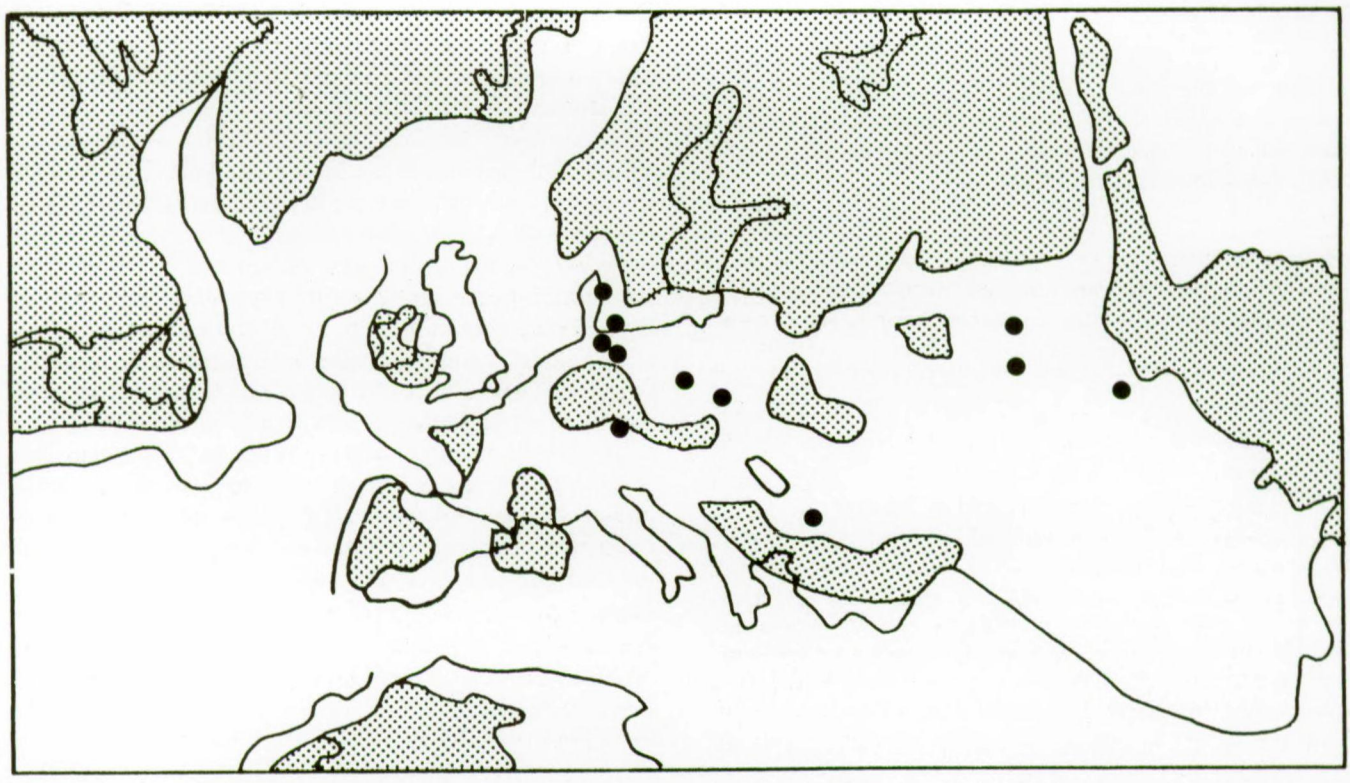
Diagnosis : medium-sized to relatively large, convex, suborbicular to subovate *Pseudolimea* species with 20 to 40 triangular ribs, with sharp summits.

Ornamentation : – to 40 ribs, triangular in cross-section, with sharp summits, separated by flat, seemingly smooth intervals; the ribs are slightly wider than the intervals on the anterior side, but much wider than the intervals on the posterior side; at the summit of the ribs, at regular intervals, lie very small spheres : they are situated at the intersection of the ribs with the commarginal growth lines; towards the areas the ribs become broader and flatter; on the steepest area (posterior area of the right valve) they tend to fade; the ribs lie more closely together on the posterior half of the shell than on the anterior ; on the areas riblets are sometimes present.
– commarginal striation covers the whole disc, but it is more clearly visible on the areas (and auricles) where radial ornamentation is less pronounced.
Umbones : relatively narrow : 60 - 90° on the specimens on which they could be measured.
Auricles : subequal, outer auricular margin somewhat recurved; hence, on that side the auricles are acute-angled; auricular riblets are sometimes present.

Discussion :
Variability : – size : the species seems to reach larger dimensions around Maastricht in the Maastricht Fm. (Late Maastrichtian) than in other areas. This is also true for other bivalves : the ecological conditions around Maastricht at that time must have been exceptionally favourable.
– umbones : the relatively wide variability reflects the lack of accuracy in the measuring techniques as much as it does the reality of the shells; also the smooth transition from the auricles to the disc margin makes the delimitation of the umbonal angle difficult.
– disc shape : small specimens are orbicular and the difference between anterior and posterior areas is hardly noticeable on them; larger specimens are opisthocline.
– rib number : varies widely (20 to 40) because the number of areal ribs increases with the shell size; the human factor influences the number of ribs in so far that it is easier to count ribs on larger specimens, and thus on such specimens the counting is done more precisely.
Synonymy : Hennig (1897) proved the identity, hinted at by Nilsson (1827) himself, of *Limea denticulata* and *L. pusilla*. d'Orbigny's (1847) *Lima dutempleana* is unmistakably synonymous with *L. denticulata,* according to the description and figures (the type being untraceable). *L. pectinata* of the same author is not so easy to interpret : the description and figures represent a seemingly narrower species; without the original material the problem cannot be solved.
Comparison : The undivided triangular ribs of *Limea denticulata* distinguish it clearly from *L. composita* (Sowerby) and from *L. granulata* (Nilsson). *L. geinitzi* (von Hagenow, 1842) also has undivided ribs, but they are rounded in cross-section and far more numerous than in *L. denticulata*. The species which seem to be most similar with *L. denticulata* are the North American species *L. reticulata* (Forbes, 1845) from the Campanian-Maastrichtian of New Jersey, and *L. serrata* (Gardner, 1916) from the Monmouth Fm. (Maastrichtian) of Maryland. Their rib number is comparable, but the rib shape of *L. reticulata* is more rounded. *L. serrata* has ribs which seem to be triangular and with sharp summits. More cannot be said without studying the original material of Gardner.

Generic Attribution :
None of the specimens of *L. denticulata* (Nilsson) which I have studied show the pseudo-taxodont denticles clearly; on the specimens at Maastricht which have the best preservation available to me, a shell layer is missing on the interior of the shell; probably the denticles were part of that layer.

Geographical and stratigraphical distribution :
Santonian (?) to Maastrichtian; frequent in sandy, coarse-grained sediments; very rare in the "Schreibkreide".
– Santonian : GDR : Salzberg b. Quedlinburg (B).
– Campanian :
France : Dieu-le-fit, Drôme (B);
GFR : Haldem, Westfalen (B, coll. Münster), Lauingen b. Königslutter - Steindorenberg, Bahnwartershaus 12 (B).



Text-Figure 6 : *Palaeogeographic distribution of* Limea (Pseudolimea) geinitzi *(von Hagenow, 1842). Palaeogeographic reconstruction at 80 million years from* Barron et al., *1981.*

Sweden : Ignaberga (B), Karlshamm (KO), Kjuge (KO), Ostra Sönnarslöv, Kristiansstad (KO).

– Maastrichtian :
Belgium - The Netherlands : Maastricht (B), Neder-Kanne (KBIN), Sint-Pietersberg (BM, KBIN), Slenaken (KBIN), Valkenburg (KBIN).
Denmark : Skovbakken, Aalborg (KO).
GFR : Hemmoor (Hann).

Limea (Pseudolimea) geinitzi (von Hagenow, 1842)
(Pl. 1, Fig. 5, Text-Figure 6)

v* 1842 *Lima Geinitzi* nob. - von Hagenow, p. 556, figs. 13a, b.
. 1850 *Lima Bronni* m. - Alth, p. 242, pl. 12, fig. 26.
v. 1869 *Lima Bronni,* Alth - Favre, p. 139, pl. 12, fig. 21.
v. 1873 *Lima Geinitzii* Hag. - Lahusen, p. 257, pl. 6, fig. 5.
v? 1891 *Limea nux* Gümbel sp. - J.Boehm, p. 87, pl. 3, figs. 34, 34 a.
v. 1902 *Lima Geinitzi* v. Hagenow - Ravn, p. 98, pl. 2, fig. 19.
. 1912 *Lima Geinitzi* v. Hagenow - Lopuski, p. 202, 216, pl. 2, fig. 1.
1923 *Lima (Plagiostoma) Geinitzi* v. Hag.- Jessen & Odum, p. 33.
v. 1932 *Lima (Limea) geinitzi* v. Hagenow - Wolansky, p. 21, pl. 3, figs. 4, 5.
v. 1968 *Limatula (Limatulella) geinitzi* (Hagenow) - Pasternak, p. 184, pl. 38, fig. 3.
v. 1977 *Limaria (Limatulella) geinitzi* (Hagenow, 1842) - Sobetzki, p. 115, pl. 7, figs. 9-10.
v. 1982 ? *Pseudolimea geinitzi* (F. von Hagenow, 1842) - Dhondt, p. 89, pl. 4, fig. 2.
. 1986 *Limea geinitzi* (v. Hagenow) - Abdel-Gawad, p. 159, pl. 36, figs. 8, 9.

TYPE-MATERIAL

Lima geinitzi : the bulk of the von Hagenow coll. at Stettin (Szczecin, Poland) was destroyed during the 1939-1945 war; in the Ernst-Moritz-Arndt Universität at Greifswald (GDR) one specimen of *L. geinitzi* from the von Hagenow coll. is still extant and it is therefore designated here as the lectotype.
Lima bronni : probably lost.
Lima nux : the specimen described and figured by Boehm (1891) is in the Bayerische Staatssammlung für Historische Geologie und Paläontologie in Munich, GFR; whether this specimen is also Guembel's type I have not been able to ascertain.

LOCI TYPICI AND STRATA TYPICA

Lima geinitzi : Rügen, GDR, Lower Maastrichtian.
L. bronni : Lemberg (= Lwow), Western Ukraine, USSR, Lower Maastrichtian.
L. nux : Gerhardtsreiter Graben, Siegsdorf, Oberbayern, GFR, Maastrichtian.

ORIGINAL DESCRIPTIONS

Lima geinitzi : "Schief Ei-rund, stark gewölbt, vorne etwas zugespitzt. Die Schloss-Kanten gerade, die vordere um 1/3 länger als

die hintere; der Schlosskanten Winkel nahe 85°. Etwa 50 nicht zerspaltene Rippen bedecken die Schale bis auf einen schmalen Raum, der am hinteren Rande frei bleibt und nur von gedrängten Anwachs-Streifen bedeckt ist, die in den gleichbreiten Zwischenräumen der hinteren Schaalen-Hälfte als queer-elliptische Grübchen, auf der vorderen aber als ausstrahlenden Perlen-Reihen erscheinen. Länge 5''' 4''', Breit 5'''."

Lima bronni : "L. testa-ovali, obliqua, convexa, radiatim costulatis, costulis numerosis (40) simplicibus, rotundatis, interstitiis angustioribus; striis concentricis elevatis numerosissimis super costulas earumque intersticia decurrentibus, in interstitiis magis conspicuis, linea cardinali recta, auriculis parvis obtusangulis. Dim. Länge und Breite 12 Mill., Dicke 6 Mill. Länge der Schlosslinie 6 Mill.
Schief-eirund, ziemlich gewölbt mit stumpfen, wenig vorstehenden Buckeln und gerader an beiden Enden geöhrter Schlosslinie, hinter steiler abfällend. Die Schlosskanten sind gerade, die hintern um ein Drittheil länger als die vordern, ihr Winkel ist gleich. Sie gehen allmählig in den, eine schief nach hinten gerichtete Ellipse bildenden Rand über. Die Schale ist dünner, innen glatt, von Aussen radial gerippt und concentrisch linirt. Die Radialrippen, 40 an der Zahl, sind einfach, gerundet, ihre Zwischenräume schmäler als sie selbst, die concentrischen Linien sind sehr genähert, erhaben und scharf, sie laufen über Rippen und Zwischenräume ununterbrochen fort, sind aber auf den Rippen, denen sie, besonders an den Seiten, ein gekörneltes Aussehen geben, viel weniger scharf als in den Zwischenräumen, die dadurch wie Reihen etwas in die Quere gezogener schmaler Grübchen erscheinen. Die Radialrippen hören etwas vor dem vordern Ohre auf, die concentrischen Linien gehen aber über dasselbe und sind hier noch gedrängter, als auf der übrigen Schale. Am hintern Ohre ist die im Ganzem lichtbraune Schale weggebrochen. Sehr selten bei Lemberg. Häufiger ist eine Abänderung dieser Species, welche fast um die Hälfte kleiner, und regelmässig schwarz und weiss gefleckt, sonst aber nicht verschieden ist. An diesen kleinen Exemplaren sieht man es deutlich, dass die Radialfalten auch vor dem hintern Ohre aufhören, während die concentrischen Linien darüber weggehen. Die Länge dieser Exemplare 7, ihre Breite 8 Mill."

ADDITIONAL DESCRIPTION

Number of specimens studied : 72.
Campanian ? : Poland (1); Maastrichtian : Denmark (12), GDR (11), GFR (17), Poland (7), USSR (26).

Measurements : The small size and the brittleness of the specimens make their measuring difficult. Danish specimens (various localities) (KO coll.) :

UPD	W	AA	R
5.0 mm	–	–	–
7.0 mm	–	–	–
8.9 mm	9.4 mm	81°	65
9.5 mm	7.4 mm	–	–
9.8 mm	9.4 mm	–	–
10.0 mm	8.6 mm	78°	–
13.9 mm	14.2 mm	75°	–

According to WOLANSKY (1932) on Rügen specimens UPD and W vary from 9 to 13 mm; I did not see her specimens, but the only specimen from Rügen which I could measure had a UPD of 3.6 mm.

Hemmoor specimens (Hann) have UPD values between 4 and 6 mm. Ukrainian specimens from near Lwow (Lwow) : only the largest specimen was measured : UPD = 9 mm, W = 8.4 mm, AA = 78°.

Diagnosis : small, subovate to suborbicular *Pseudolimea* species covered with numerous (40-65) generally rounded, undivided ribs.

shape : varies from suborbicular to subovate, but generally the valves are obliquely subovate (opisthocline).
ornamentation : the very numerous radial ribs are undivided and seem to have the same width in the median and lateral parts of the disc; the intercostal intervals are twice as wide as the ribs; the shell is covered with commarginal striae which are clearly visible as slight elevations in the intercostal intervals; the areas are almost completely covered with ribs, but those ribs are less strongly developed and the concentric striation is more pronounced than on the central part : as a result the areas give the impression of being covered with little quadrangles.
auricles : small, subequal and devoid of ribs, but covered with commarginal striation.
hinge margin : straight.

Discussion :
Variability : *Limea geinitzi* seems to have fairly constant characteristics; only the ribnumber varies relatively widely : 40 to 65. This variation can partly be explained by the human factor : different authors count ribs in different ways (taking areal ribs into account or not, and using or not using magnifying equipment). The proportion UPD/W varies seemingly but probably some of the specimens are squashed, which would explain the variation.
Synonymy : PASTERNAK (1968, p. 185) demonstrated the identity of *Limea geinitzi* and *Lima Bronni* ALTH, 1850.
I have studied the originals of *Limea nux* as described and figured by J. BOEHM : their preservation is not perfect and does not allow a definite conclusion, but better preserved specimens might show them to be *L. geinitzi* specimens (as indeed J. BOEHM's description seems to indicate).
Comparison : among the *Limea (Pseudolimea)* species from the Late Cretaceous strata, *L. (Pseudolimea) geinitzi* is the species with the highest number of ribs; by the smoothness of the ribs, by their number, and by the relatively small size of the shells it can easily be distinguished from other Late Cretaceous *Limea (Pseudolimea)* species *L. (Pseudolimea) geinitzi* appears to be scarce, but this is induced by its small size and by its brittleness. Mesofraction study such as done in Hemmoor does not give information about the frequency in the sediment of this species, because fragments of *L. (Pseudolimea) geinitzi* and of *Limatula* species cannot be distinguished from one another.

Generic Attribution :
None of the specimens of *Limea (Pseudolimea) geinitzi* which I have studied, have a visible hinge with denticles; some authors [PASTERNAK (1968), SOBETZKI (1977)] placed

this species in the subgenus *Limatulella* Sacco, 1898. According to Cox & Hertlein (Treatise, 1969, p. N389), *Limatulella* is characterised by "ornament of weak unequal radial riblets"; I consider that this qualification does not apply to the equal, rounded ribs of von Hagenow's *Lima Geinitzii* and therefore place the species in *Limea (Pseudolimea).*

Geographical and stratigraphical distribution :
Limea (Pseudolimea) geinitzi is a typical "Schreibkreide" species. The possible occurrence in the Maastrichtian of the Bavarian Alps, outside the "Schreibkreide" facies is not totally surprising : other "northern" faunal elements have been found in those deposits (Schmid & Schulz, 1979).

? Upper Campanian :
– Poland : Dorotka (MuzWars).
Maastrichtian :
– Denmark : Aalborg (KO), "Dania", Mariagerfjord (KO), Kastrup (KO), Møen (DR, KO, SM), Nørre Flødal (KO), Smidie (KO), Stevns Klint (KO).
– GDR : Rügen (GR, including lectotype of von Hagenow, NMW).
– GFR : Hemmoor (Hann), Lüneburg-Zeltberg (Hann, NMW), Siegsdorf, Gerhardtsreiter Graben (Mü, orig. J.Boehm, 1891, pl. 3, figs. 34, 34a : *Limea nux*).
– Poland : Janowiec (MuzWars), Lukow (Instgeol), Slowaczow (Instgeol), Sochachew (Instgeol).
– USSR : - near Lwow, western Ukraine : s. Zavachive (figured in Pasternak, 1968, MusLwow), Stara skvarava (MusLwow), Lwow (Favre 1869 specimen, NMW);
- Crimea, southern Ukraine : s. Staroselje, s. Tchursuk Su (both mentioned in Sobetzki, 1977, PIN);
- Middle Volga, Jazikovo, Ulyanovsk Oblast (orig. material Lahusen, Gorniinst);
- deposits on the Lower Volga, Saratov Oblast (MGU);
- Aktiubinsk region, Precaspian depression, Kazakhstan (Sobetzki Coll., PIN).

***Limea (Pseudolimea)* spec. of the *L. (Pseudolimea) granulata denticulata* lineage from Crimea.**

In the material of Campanian-Maastrichtian age from Crimea, along with specimens of *Limea (Pseudolimea) geinitzi,* there are specimens belonging to another *L. (Pseudolimea)* species with fewer and wider ribs. In 1977, Sobetzki described and figured a new species *Limea (Pseudolimea) postcomposita* (p. 108, pl. 7, fig. 4) : according to the description this new taxon seems very close to *L. (Pseudolimea) denticulata* (Nilsson). The type material, at present in Moscow (PIN) does not confirm the impression gleaned from the publication : the preservation of the material is steinkern and gives no idea of the precise shape of the ribs. Those specimens and others from Crimea belong to a *Limea (Pseudolimea)* species which will remain uncertain until specimens with shell preserved are found. Such specifically unidentifiable specimens have been seen from the Campanian of Besh Kosh, from the Maastrichtian of Belaja Skala, Bodrak and Tchakh Makhli all in Crimea. The specimen described from Aktcha Kuju as *Lima* cf. *circularis* by Eichwald (1867, p. 67, LGU coll.) probably also belongs here.

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Appendix

List of Museum collections studied and abbreviations used for them :

B	:	Paläontologisches Museum der Humboldt Universität, Naturkunde Museum, Berlin, GDR.
BM	:	Mollusca Section, Department of Palaeontology, British Museum (Natural History), London, GB.
DR	:	Staatliches Museum für Geologie und Mineralogie, Dresden, GDR.
GeolSci	:	Geological Sciences Institute, London, GB.
Gorniinst.	:	Gorni Institute, Leningrad, USSR.
GR	:	Sektion Geologische Wissenschaften der Ernst-Moritz-Arndt Universität, Greifswald, GDR.
Halle	:	Paläontologisches Museum (Geiseltal Museum) der Martin-Luther Universität Halle Wittenberg, Halle-an-der-Saale, GDR.
Hann	:	Geologisches Landesamt für Bodenforschung, Hannover, GFR.
Instgeol	:	Instytut geologiczny, Warsaw, Poland.
KBIN	:	Section of Mesozoic and Cainozoic Invertebrates, Department of Palaeontology, Koninklijk Belgisch Instituut voor Natuurwetenschappen - Institut royal

des Sciences naturelles de Belgique, Brussels, Belgium.

KO : Geologisk Centralinstitut, University of Copenhagen, Denmark.

LGU : Department of Geology, Leningrad State University, Leningrad, USSR.

Mans : Laboratoire de géologie, Université du Maine, Le Mans, France.

MGU : Faculty of Geology, Moscow State University, Moscow, USSR.

Mü : Institut für Paläontologie und historische Geologie, Bayerische Staatssammlung, Universität München, Munich, GFR.

MusGen : Muséum d'Histoire naturelle de Genève, Geneva, Switzerland.

MusLaus : Musée géologique, Lausanne, Switzerland.

MusLwow: Monographic palaeontological collections of the natural history Museum of the Ukrainian Academy of Sciences, Lwow, USSR.

Musé : Institut de Paléontologie, Muséum national d'Histoire naturelle, Paris, France.

MuzWars : Muzeum Ziemi, Polska Akademia Nauk, Warsaw, Poland.

NMW : Geologisch-paläontologische Abteilung, Naturhistorisches Museum Wien, Vienna, Austria.

PIN : Palaeontological Institute of the USSR Academy of Sciences, Moscow, USSR.

RE : Ruhrland Museum, Essen/Ruhr, GFR.

RM : Roemer-Pelizaeus Museum, Hildesheim, GFR.

SM : Department of Earth Sciences, Sedgwick Museum, Cambridge, GB.

Tüb : Institut und Museum für Geologie und Paläontologie, Tübingen, GFR.

Abbreviations used in the text :

UPD : umbo pallial diameter of the discs.

W : width of the discs.

AA : apical angle (= umbonal angle).

R : ribs, number of ribs.

HM : hinge margin.

Signs used in synonymy lists :

see DHONDT, 1972 a, p. 5

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PLATE 1

Figure 1 : Limea (Pseudolimea) granulata *(NILSSON, 1827), × 4, positive of natural mould, latest Cenomanian, Oberposterwitz, Pennrich, Saxony, GDR (KBIN TCM 10112).*

Figure 2 : Limea (Pseudolimea) granulata *(NILSSON, 1827), × 4, positive of natural mould, latest Cenomanian, Oberposterwitz, Pennrich, Saxony, GDR (KBIN TCM 10113).*

Figure 3 : *Detail of* Limea (Pseudolimea) granulata *(NILSSON, 1827), × 12, positive of natural mould, latest Cenomanian, Oberposterwitz, Pennrich, Saxony, GDR (KBIN TCM 10113).*

Figure 4 : *Detail of* Limea (Pseudolimea) granulata *(NILSSON, 1827), Late Campanian (Craie d'Obourg), Harmignies, Hainaut, Belgium (KBIN TCM 10101) 4a : × 10; 4b : × 25.*

Figure 5 : Limea (Pseudolimea) geinitzi *(von HAGENOW, 1842), × 3, Late Maastrichtian, Hemmoor, GFR. (Hann).*

Figure 6 : Limea (Pseudolimea) granulata *(NILSSON, 1827), × 4, Late Campanian (Craie d'Obourg), Harmignies, Hainaut, Belgium (KBIN TCM 10101).*

Figure 7 : Limea (Pseudolimea) denticulata *(NILSSON, 1827), × 3, latest Maastrichtian, Sint Pietersberg, The Netherlands (KBIN TCM 10209).*

Figure 8 : Limea (Pseudolimea) denticulata *(NILSSON, 1827), × 3, latest Maastrichtian, Sint Pietersberg, The Netherlands (KBIN TCM 10207).*

Figure 9 : Limea (Pseudolimea) denticulata *(NILSSON, 1827), × 10, latest Maastrichtian, Sint Pietersberg, The Netherlands (KBIN TCM 10105).*

Figure 10 : Limea (Pseudolimea) granulatissima *(WOLLEMANN, 1896), × 2, "Neocomian", Schöppenstedt, GFR (RM).*

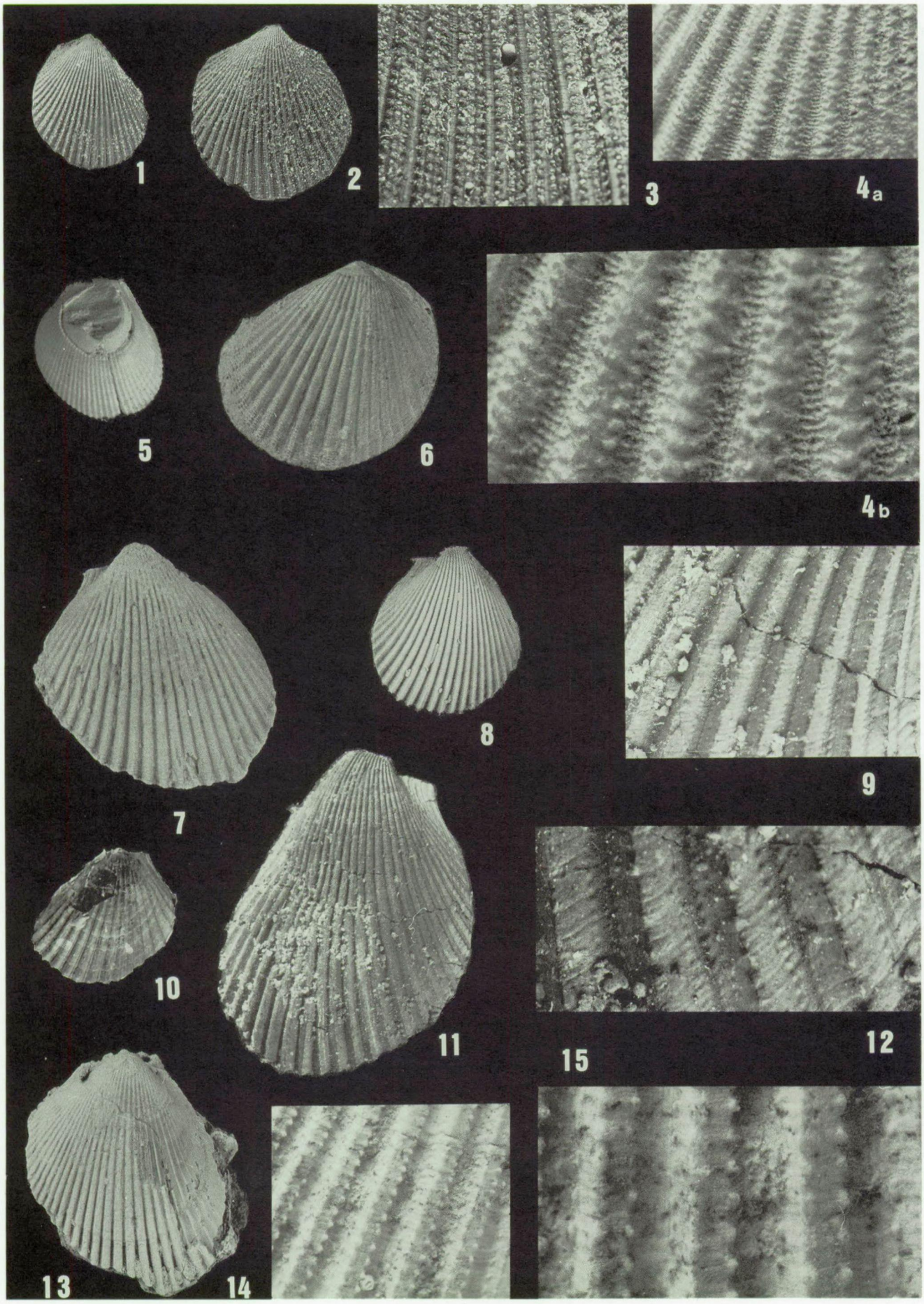
Figure 11 : Limea (Pseudolimea) denticulata *(NILSSON, 1827), × 4, latest Maastrichtian, Sint Pietersberg, The Netherlands (KBIN TCM 10105).*

Figure 12 : *Detail of* Limea (Pseudolimea) denticulata *(NILSSON, 1827), × 20, latest Maastrichtian, Sint Pietersberg, The Netherlands (KBIN TCM 10105).*

Figure 13 : Limea (Pseudolimea) composita *(SOWERBY, 1836), × 4, Tourtia de Tournai, Cenomanian, Tournai, Hainaut, Belgium (KBIN TCM 10208).*

Figure 14 : *Detail of* Limea (Pseudolimea) composita *(SOWERBY, 1836), × 10, Tourtia de Tournai, Cenomanian, Tournai, Hainaut, Belgium (KBIN TCM 101O6).*

Figure 15 : *Detail of* Limea (Pseudolimea) composita *(SOWERBY, 1836), × 25, Tourtia de Tournai, Cenomanian, Tournai, Hainaut, Belgium (KBIN TCM 10106).*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